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APPROACHES TO WATER RESOURCES DEVELOPMENT IN DEVELOPING COUNTRIES

By The Department of Economic and Social Affairs,
United Nations,
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APPROACHES TO WATER RESOURCES DEVELOPMENT IN DEVELOPING COUNTRIES

by

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United Nations, New York

1. In view of the basic importance of water to life and to any economic development activity every developing country is, or should be, concerned with the development of water resources. The rapidly growing interest in this field is reflected in government development plans and also in requests for technical and financial assistance to the United Nations organizations concerned.[1/] The present paper concentrates on a few salient points shown by United Nations experience to be particularly important, primarily as related to formulation and implementation of water development policies.

2. Particular attention deserves to be given to formulation of water policy and development decisions, and to the companion problems of organization to implement them, for several reasons, among them the facts that the key to success lies in this area and that a comprehensive approach is often lacking. Sound water policy is based on an adequate factual knowledge, which in the first instance requires the undertaking of surveys of current water uses and future needs and appraisals of water resources. In this process account should obviously be taken of new concepts for water resources development and new techniques. This paper briefly reviews the various aspects of a water policy. Before dealing with each of them, however, it is important to stress several basic characteristics, some of which distinguish water resources development from that of other natural resources and which influence the policy problems and their solutions.

Some basic characteristics

3. All countries have water resources. Many have too little water, some too much at least at certain times. The water needs and the urgency of water resources development differ with stage of development and type of area, such as illustrated by differences between humid tropical and arid areas. Hence the problems range from provision of drinking water at least, to coping with floods. In addition to the primary need for drinking water,

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1/ Activities of the various United Nations organizations in this field are described in the first and second biennial reports of the United Nations Water Resources Development Centre, which is located at United Nations Headquarters and acts as the focal point for co-ordination and exchange of experience.

there are the problems of developing water supplies for industrial, agricultural and other uses, and of putting water resources to use for hydro-electric production, navigation, fishing, recreation and other purposes. Many of these needs have in the past been met through single-purpose development but are now approached to an increasing extent through multi-purpose schemes. The modern approach also considers alternative solutions, where feasible, and in this connexion is guided by comparative cost studies. In fact, the problems are often not so much purely technical as administrative, organizational and economic, notably when water is scarce and priority allocation to different uses has to be made.

4. There is usually no substitute for water, only techniques for economizing use such as by re-use and alternative processes or by metering and other price policy devices.

5. Water is an extremely bulky "commodity". It can be economically transported over only limited distances. It hardly enters foreign trade and is free from foreign exchange considerations, except as regards equipment for water resources development and utilization. Water has to be supplied from more or less local resources, where available, so that industrial and other potential users normally have to be located near the water resources, as illustrated since time immemorial by the concentration of populations in river valleys. In many aspects problems of water needs and supply thus have to be approached on an area and local basis even in relatively small countries; in some cases, however, the unit to consider is a whole hydrographic basin, which can indeed be large and also involve special problems as in the development of international river basins.

6. Except for some types of ground water, water resources are renewable, through replenishment provided by the balance between precipitation and evapotranspiration in the hydrologic cycle. The replenishment, and consequently the potential supply particularly in the case of surface water, vary with season and over the years in a not completely predictable fashion.

7. A large part, and in some countries the great bulk, of water use is non-consumptive, that is the water is not eliminated by its use from the total water supply of an area. Most of the water used for municipal and industrial purposes is non-consumptive water and remains available for re-use, although it may require reconditioning because of pollution, temperature and other quality changes before it can be used for subsequent purposes. Sometimes the water is not even changed in quality or little affected in this respect, as in the case of navigation, fishing and recreation. Hydro-power production leaves the water unchanged except for its altitude. Consumptive uses, on the other hand, eliminate water from the supply and therefore may have to be looked upon differently in policy formulation and planning. The most important application in this category is irrigation, in which water is used only once and mostly becomes either a part of the crop or, more importantly, is largely lost.

8. Water resources development and utilization must be planned years ahead in anticipation of population increase and economic growth. Considerable time is required for planning and construction, particularly in surface water development; hydrologic data, for example, usually have to be collected over

many years for the proper and safe design of large-scale structures. Moreover, foresight and early action are required to ensure adequate flexibility in access to water resources, which are often barred to potential users by antiquated water laws or traditional rights in the absence of water law. Delays only serve to strengthen vested interests of uses and of local water agencies possibly mushrooming in a haphazard fashion, as has happened in industrial countries, for lack of a comprehensive approach to water resources development.

Surveys of current water uses and future needs

9. Since water resources development aims at meeting needs, it is important first of all to have a reasonably clear picture of what those needs really are and may be expected to be. This side of the ledger is often neglected, partly because it is relatively difficult to assess present and especially future needs; this requires the skill to take account also of development planning, cost and value of water for different uses and problems of forecasting.[2/] Also, the "demand" side may be neglected for lack of a competent organization or authority to carry out comprehensive surveys in the face of pre-occupation with partial interests such as sanitation, irrigation or hydropower production in functional ministries. Still such surveys are essential to policy formulation and also to guide the survey of water resources going ahead simultaneously. Stress must thus be laid on undertaking as early as possible at least a general assessment of the present and future water needs of each sub-region of the country.

10. Based on a division of the country into regions, normally corresponding to hydrographic basins, the comprehensive survey seeks to account for the water requirements in terms of those of human consumption, various branches of industry, mining, irrigation, stock-raising, power production, etc. The inventory may start with an investigation into present uses, which unfortunately in most cases are poorly documented with statistics. The picture then may be built up with information on population trends, industrial and other development plans and various methods of projection. The quantity requirements may be established with the aid of key figures on present and expected per capita use as regards human requirements, similar data for different types of industries, irrigation crops, processes, etc.[3/] Close attention must also be paid to the water quality requirements, which vary greatly between and within major functional sectors; in industry, for example, a high degree of purity is required for water entering food or pharmaceutical products while sea water is frequently used for cooling in thermal power and other plants. Similarly, careful consideration may have to be given to the effect the prospective use will have on subsequent availability and quality. Keeping

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2/ The forecasting is complicated by the fact that a discovery of new water resources may create a corresponding actual demand, as in very arid areas or where lack of water is the factor limiting development.

3/ Key figures on water requirements per unit of product in selected industries, for example, are available in Water for Industrial Use, United Nations publication, Sales No.: 58.II.B.1.

in mind re-use of water and the problem of supply generally, it is of course essential to indicate the location of major users in the sub-region so that information is obtained for instance as to whether it is proposed to locate a "dirty" industry upstream from another requiring clean water and as to the relative location of major consumptive and non-consumptive users; for example by locating an irrigation project using up water upstream a major industry downstream may be left without adequate water supply while with the opposite location the industry may use the water first before it goes to irrigation.4/ The survey should also bring in information on current costs of water and the water costs which different current and prospective uses can stand.

11. This survey, when coupled with the simultaneous survey of water resources, will be basic to water policy considerations and probably a whole series of decisions. In water-short areas, for example, it will pinpoint mutually competitive needs at present and in later stages of the prospective development. The results may necessitate reconsideration of industrial and other development plans, changes of water laws and other decisions; if obtained sufficiently early, they will permit timely planning before acute problems arise.

Surveys of water resources

12. The surveying of water resources is a never-ending task. It is undertaken in stages ranging from broad preliminary reconnaissance to detailed investigations, feasibility studies and planning in preparation for actual development decisions. Geographical and topographical distribution and other features of water resources are related to demand areas; work is of course concentrated on useful water resources, in co-ordination with surveys of needs, so as to make the survey results helpful for policy and planning decisions.

13. The surveys should cover both surface-water and ground-water resources in a co-ordinated whole whether they are undertaken by one or several agencies. With respect to both types of resources there are now available many new techniques and tools as a result of advances in scientific hydrology, geophysics and other disciplines.5/ The surveys may be built up into an inventory or a more formal, perpetual cadastre registering not only the results of the initial survey but gradually also information on water use and other aspects such as water rights.

4/ In this connexion it should of course not be overlooked that e.g. new industries in themselves using relatively little water may bring with them significant urban development requiring large water supply.

5/ For comprehensive reviews, see for example respectively World Meteorological Organization, Techniques For Surveying Surface-Water Resources, Technical Note No.26, Geneva (1958), and United Nations Water Resources Development Centre, Large-Scale Ground-water Development, United Nations publication, Sales No.60.II.B.3. For further detail, reference is also made to papers under Agenda Items A.3.2 and A.3.3.

14. In locating and classifying water resources, data should be obtained as to both quantity (over time) and quality, including saline water which may be used directly for example in certain industries or converted at a cost to fresh water. In its more complete form, the survey will include adequate information on hydro-power potentials, possibilities for navigation and other development opportunities.6/ Stress will be laid on finding water supplies which have not been allocated.

15. As the resources surveys progress they will have to go into greater detail of physical data and especially give more consideration to economic factors required for appraisals, feasibility and planning studies. Beginning with rough estimates of costs of potential development they proceed to more exact information for promising resources, including breakdowns of costs for dams or wells, distribution systems and so forth. In this connexion it may be noted that the investment required in the development of the resource proper is only the beginning and may have to be accompanied by far larger investment for subsequent stages.7/ Early attention is also advisable with regard to the magnitude of foreign exchange costs in the prospective water resources development, for example for multi-purpose water structures, wells, pipes and so on. Sometimes there will be alternative ways, which should be looked out for, in meeting particular needs; they may differ in total cost or at least in composition as to foreign exchange requirements, labour and capital intensity and other factors of importance in the country's total development effort.

16. Already the reconnaissance survey will in all likelihood indicate many gaps in the knowledge of water resources, as has been the case in country surveys undertaken with United Nations assistance; several of these have since been followed with the establishment of hydrometeorological networks and similar projects, aided by the United Nations Special Fund, to help fill the gaps.

17. Country surveys of water resources, besides being essential to comprehensive water policy formulation, will have many beneficial effects. Their results will indicate solutions to present needs, be a useful guide to selection and location of industries and other activities, and in general create a better consciousness of water limitations and possibilities.8/ The resources surveys form an important first step towards development of water supply making possible new settlements, better health, increased agricultural production, new industries and other benefits for the developing economy.

6/ As regards hydro-power potentials it may be of interest to note that on the basis of inadequate exploration it is estimated that less than 10 per cent of the potential in Latin America is utilized and in Africa and Asia less than 5 per cent.

7/ In the overall experience of public water utilities in the United States, for example, pumping stations, distribution systems and filter plants - that is, stages after the development of the resource itself - account for over 80 per cent of the total investment.

8/ This consciousness may lead to avoidance of surprises such as are known to have happened in some cases where plans have been drawn in detail for particular industries - with water supply taken for granted - and then been upset upon discovery that adequate water was not available or cost too much

New techniques and concepts for water resources development

18. The evolution of new techniques in the development as well as in the exploration stages, has made approaches on a different scale possible and led, in a continuous process of inter-action, to revisions of the concepts underlying modern utilization and water management.

19. The advances on the technical side can be but briefly referred to here by way of a few examples. Surface-water development, for instance, has been profoundly affected by modern earth-moving equipment and possibilities opened by improved knowledge of soil mechanics for building earth dams, not to mention methods of blasting and moving rocks and use of steel and concrete for huge dams; other advances in this category include techniques for barrages, river diversion, lock construction, new turbines and pumps, long-distance power transmission and the use of hydraulic models. Ground-water development has been advanced not only through greater accuracy in locating and assessing ground-water resources but also by modern drilling to great depths, which are limited only by economic considerations; parallel with this may be noted advancing techniques and equipment for completing wells, efficient pumps such as submersible pumps and power drives to match them as well as techniques for underground storage and ground-water recharge. Note should also be taken of advances in water treatment and ways of improving water quality, including demineralization processes and possibilities for utilizing sea and brackish water.9/

20. Integrated river basin development is among the concepts made possible by technical advances. The concept is, however, based on an integration also of economic, social, administrative and legal considerations, which cannot be entered into here.10/ It provides a framework for action involving the co-ordinated and harmonious development of the various works in relation to all the reasonable possibilities of the basin. Several steps will obviously have to be taken in the application of the concept, ranging from broad preliminary investigation to operation of new structures. Within this approach can then be accommodated both early planning on a big scale and also early implementation of small-scale projects, such as on tributaries, fitting into the bigger scheme but not needing to await the construction of main-stream dams.

21. The concept and approach will have to take into account additional problems and considerations when the river basin is international in scope. Regional and international co-operation then becomes clearly necessary for.

9/ The United Nations Department of Economic and Social Affairs currently is carrying out a survey of potential economic applications of demineralization of sea or brackish water in arid or semi-arid areas of under-developed countries experiencing fresh-water shortages. The report on this survey is scheduled for publication late in 1963.

10/ For a comprehensive study of this subject, see Integrated River Basin Development, United Nations publication, Sales No.58.II.B.3.

proper study and development of the resources, as illustrated by the Mekong River Project.[11] It is thus not surprising that international river basins are gaining increasing attention in the United Nations, which is in a unique position to assist in such cases involving several countries.

22. Ground-water development also is now increasingly approached through the application of modern concepts. It has come a long way from the traditional, sporadic production of ground water from hand-dug wells placed here and there, perhaps with the guidance of water diviners. Owing to advances in technology as well as increasing demand for water, development of ground-water resources now can be, and is, approached on a large scale spanning whole hydrogeological basins or countries. Drawing fully on relevant scientific disciplines, the approach is systematic in its entire range of stages from hydrogeological investigations and assessment through development surveys and planning to drilling of production wells, testing and maintenance. Again, it provides a framework of action which gives consideration also to organizational and other non-technological aspects and fits the various elements together whether they be geophysical surveys or the drilling of particular wells to meet pressing needs.[12]

Water policy problems

23. Water resources development is part of, and basic to, economic development. It ought to be guided by the evolution of water policy which clearly defines the aims of the State and, as a tool of economic development, is in harmony with broader goals and policies. That evolution of policy and planning decisions, in turn, are aided by the application of the approaches and considerations discussed above. The policy must be supported by a corresponding programme of action and organizational provisions to carry it out. Certain aspects will require to be expressed in water legislation.

24. The problems, contents and emphases of water policy will of course vary with local conditions and with the factual findings of the specific case. Without reference to particular place and time, they can be taken up here only by way of a few illustrations of issues and elements.

25. One set of basic problems concerns water rights, which must in most cases be clarified through water legislation along with a series of related questions. The doctrines applied in this respect range from absolute private ownership permitting unlimited use to public ownership with various systems for regulating use. Legislation on this point, as on others, should be concise and enforceable but also flexible so that effective use can be made of the resources.

11/ For a description of the project, see for example Annex II of The United Nations Development Decade, United Nations publication, Sales No. 62.II.B.2.

12/ For further details, see Large-scale Ground-water Development, United Nations publication, Sales No.60.II.B.3.

26. An important criterion in the priority allocation of water use is that of economic efficiency. This criterion, which may be resisted by vested interests, takes into account the relative contribution, per unit of water, of different uses to national income, that is to say the product value produced through the use of a given quantity of water in different potential applications, such as various industries and types of irrigation crops. Wide variations will usually be found in this respect, particularly as between industry and agriculture. If water were a normal commodity, such differences would be reflected in the market; the application of the economic productivity criterion in water allocation, in water-short areas, is in essence a substitute for the price mechanism that balances supply and demand in normal commodity markets. It can provide an impartial and effective yardstick but may need to be supplemented with special considerations, such as with regard to drinking water requirements and traditional rights in the light of long-term goals.

27. To some extent, water price policy itself may be used as an allocation tool; when coupled with metering, it can become an effective device for conservation by relating water charges to quantities used. In most cases, however, water pricing is not treated primarily from the allocation point of view but rather in relation to the problem of financing and reimbursing public investments in water resources and supply development;[13/] the latter problem of course raises a whole series of policy questions. They are not however unique to water resources development, which must be reviewed with regard to (foreign and domestic) capital, labour and other requirements like any other developments and in conjunction with them, as is done in overall economic development plans.

28. A related problem is that of appraising water resources projects and making planning decisions. In this connexion it is worth stressing the growing role of systematic economic studies as a tool and the importance of familiarity with their techniques of comparative cost analysis, evaluation of benefits and application of investment criteria.

29. Another necessary preoccupation of policy concerns conservation of water. Conservation measures range from reduction of large losses through evaporation, transpiration and run-off, to attacks on the - more controllable - losses due to wasteful uses of water, including overpumping of ground-water resources. The techniques of conservation are numerous and in fact beyond the scope of this paper except for stressing that their selection must be governed by economic considerations rather than by the aim of conservation for its own sake. The policy considerations should take into account

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13/ Water prices are in fact often subsidized; this practice may be of doubtful value in the long run, particularly since it is likely to result in mounting difficulties on account of increasing costs both for replacement works and especially for developing additional water resources and supplies.

conservation of water quality as well as quantity. In this context particular attention may be paid to re-use and reconditioning of water and to the related question of control of water pollution, which is becoming a serious problem in many places.

30. Whatever the specific water policy problems, it is necessary that the basic policy reflects long-term goals and that provision is made for sufficient flexibility permitting adaptation to changing conditions. After a comprehensive approach and policy have been worked out, there will be a need for periodic re-examinations of policy and for continuous adjustments through the organizations set up to implement water policy and water resources development.

Organizations and programme of action

31. The form and tasks of organizations in the water field reflect water policy, or lack of policy. Where a comprehensive approach is applied, there will normally be a correspondingly clear organization, with responsibilities set out in water legislation or other form, to ensure that water resources are properly explored, developed and conserved and that they are allocated fairly to the various uses.

32. The role of public water authorities varies from country to country, and so does the type of organization. The organization is related not only to the scope and contents of water policy and development programmes but also to the historically evolved structure of the central government and local conditions. The functions may be centered in a government ministry or corporation, but more commonly they are divided, partly for historical reasons, among various government ministries, departments and organizations.

33. Sometimes this division is clearly established, at least on paper, by function, such as surface-water surveys being handled by a hydrometeorological organization, ground-water exploration by a geological survey department, construction by a public works ministry, irrigation development by a ministry of agriculture, hydro-power development by another department, river navigation development by a ministry of transport, health aspects by a ministry of public health, and so forth. In practice, this division amounts to fragmentation of efforts and may result, as has happened in some countries, in the organizations working at cross-purposes without regard to other related activities and broader interests.

34. The comprehensive approach considered in this paper serves to bring order into this situation. It is emphasized particularly in relation to the less developed countries, where the organizational set-up usually is still relatively fluid and where an integrated approach to water resources development may be not only easier but also more important. The integration does not necessarily require centralization in a single department or autonomous government organization, though such an establishment may be able to carry out the most effective water resources development. But at least the efforts and programmes should be effectively co-ordinated through inter-departmental co-operation, which may be secured by means of a body at the

ministerial or other higher level or, better still, by a national water resources board. The latter type of top organization should be in an excellent position to ensure a comprehensive approach taking fully into account the various factors and interests involved and to develop water policies and programmes best serving the developing country. It must of course have adequate authority and be able to rely on a sufficiently equipped subordinate organization to implement the policies and programmes.

35. The size and scope of the staff in the water organization will of course vary from situation to situation and depend, for example, on the extent to which work is done on outside contract. Here it is only necessary to emphasize that sufficiently competent staff be acquired or developed to do the job at hand and that adequate attention be given to the training of staff to meet these needs in the developing countries. The staff must also be provided with adequate tools and equipment to be able to do a good job.

36. The effectiveness of water resources development programmes is only as good as the organization carrying them out. Governments are keenly aware of this; many of them have turned to the United Nations and other sources to meet their pressing needs, and more are becoming aware of the possibilities for assistance.

37. Hence it is not surprising that water resources development has been growing in importance in the international assistance field. It has come to include, for example, United Nations technical assistance in reviewing water policy, undertaking preliminary country surveys of water resources and needs, setting up organizations and implementing various water projects; numerous water resources surveys in the "pre-investment" category assisted by the United Nations Special Fund; and loans from the International Bank for Reconstruction and Development and its affiliate the International Development Association to finance major water development projects. In these and other related activities the various United Nations organizations concerned, as noted in the introduction, co-operate and pool their experience through the United Nations Water Resources Development Centre.

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